MATERIAL COMPATIBILITY PROGRAM

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BROOKHAVEN
NATIONAL LABORATORY

Why do we need Material Compatibility Program

- Big neutrino projects such as Daya Bay, SNO/SNO+, LENS and LBNE have liquid as the detection medium
- Requirement of certain attenuation length
- Could be accomplished by maintaining the liquid quality
- Components of the detector could deteriorate under certain conditions and different life times
- Material testing is essential since materials have different compatibility with various solvents
- Needs careful selection of the material

MATERIAL COMPATIBILTY PROGRAM

- Our goal is to study for various detectors
  - Impacts of material to liquid: UV
    - Effect the optical transparency caused by inorganic/organic components
  - Impacts of liquid to material; XRF, ICP-MS, Microscope
- 10-cm UV-VIS measurements of daily operations
  - For water, the Cerenkov light (>300 nm)
  - For organic liquid scintillator, the blue scintillation light (at 430nm)
- Kinetics model with PMT corrections at Cerenkov and blue region to interpret the 10-cm data
- Online purification system

Material Compatibility Kinetics

- Ambient compatibility testing is not enough due to the timely requirement
- The accelerated aging testing would be done at higher temp. than the detector temperature
- Aging technique is the way of analyzing the material in short period of time.
  - **For e.g. if the the detector lifetime is 10 years (t_{aging} = 2.5yrs at 40°C if Q_{10}= 2)**

Kinetics……

- First order Arrhenius rate equation
- Q_{10} is 2

$$r = Ae^{-\frac{\varepsilon}{kT}} \qquad r = Q_{10}^{\frac{T2-T1}{10}}$$

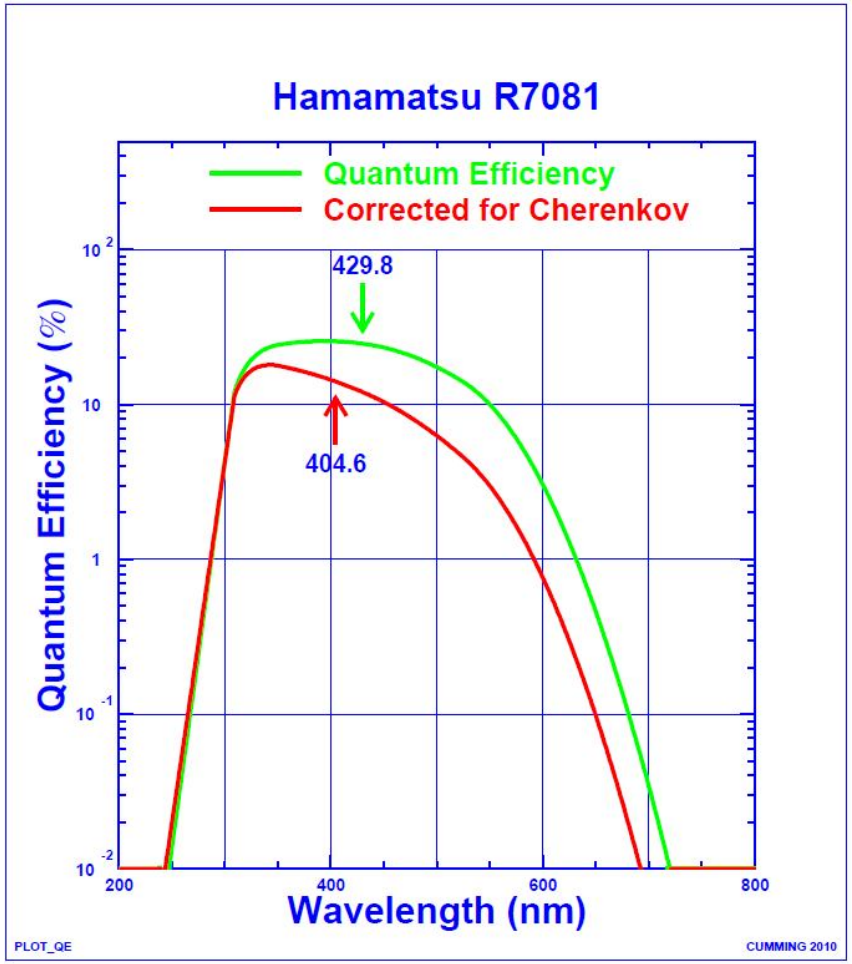
- Relationship of aging time (T_{test}) to real life time ($T_{extrapolated}$)

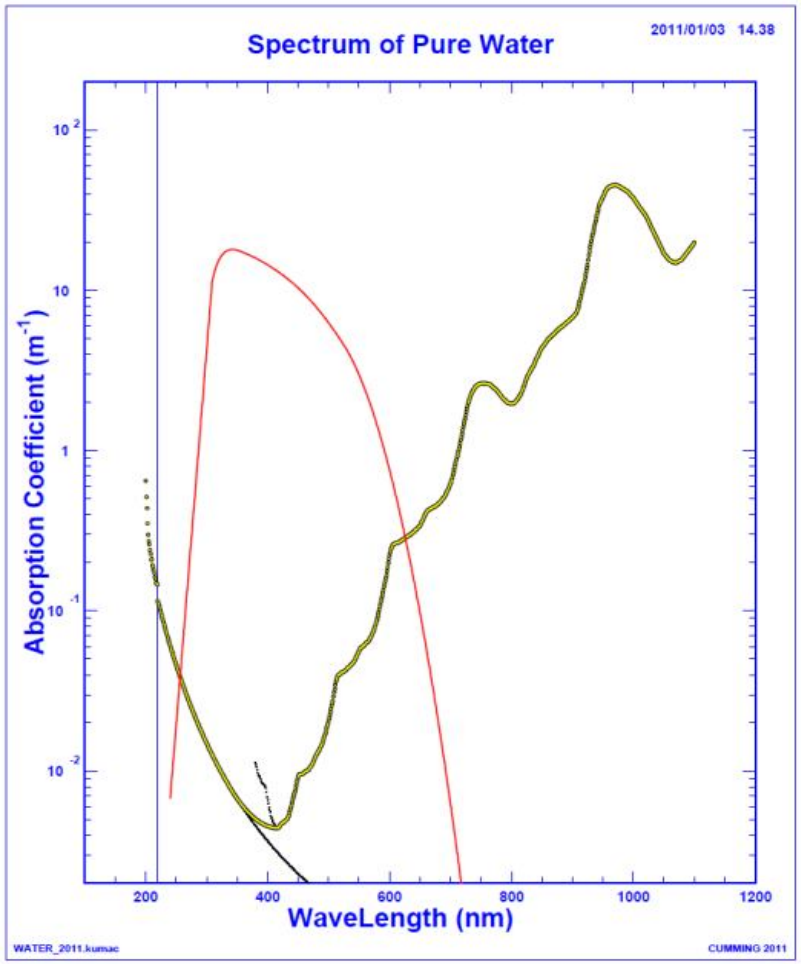
$$T_{extrapolated} = T_{test} Q_{10}^{\frac{T2-T1}{10}}$$

- T2 is the aging temperature and T1 is the ambient temperature

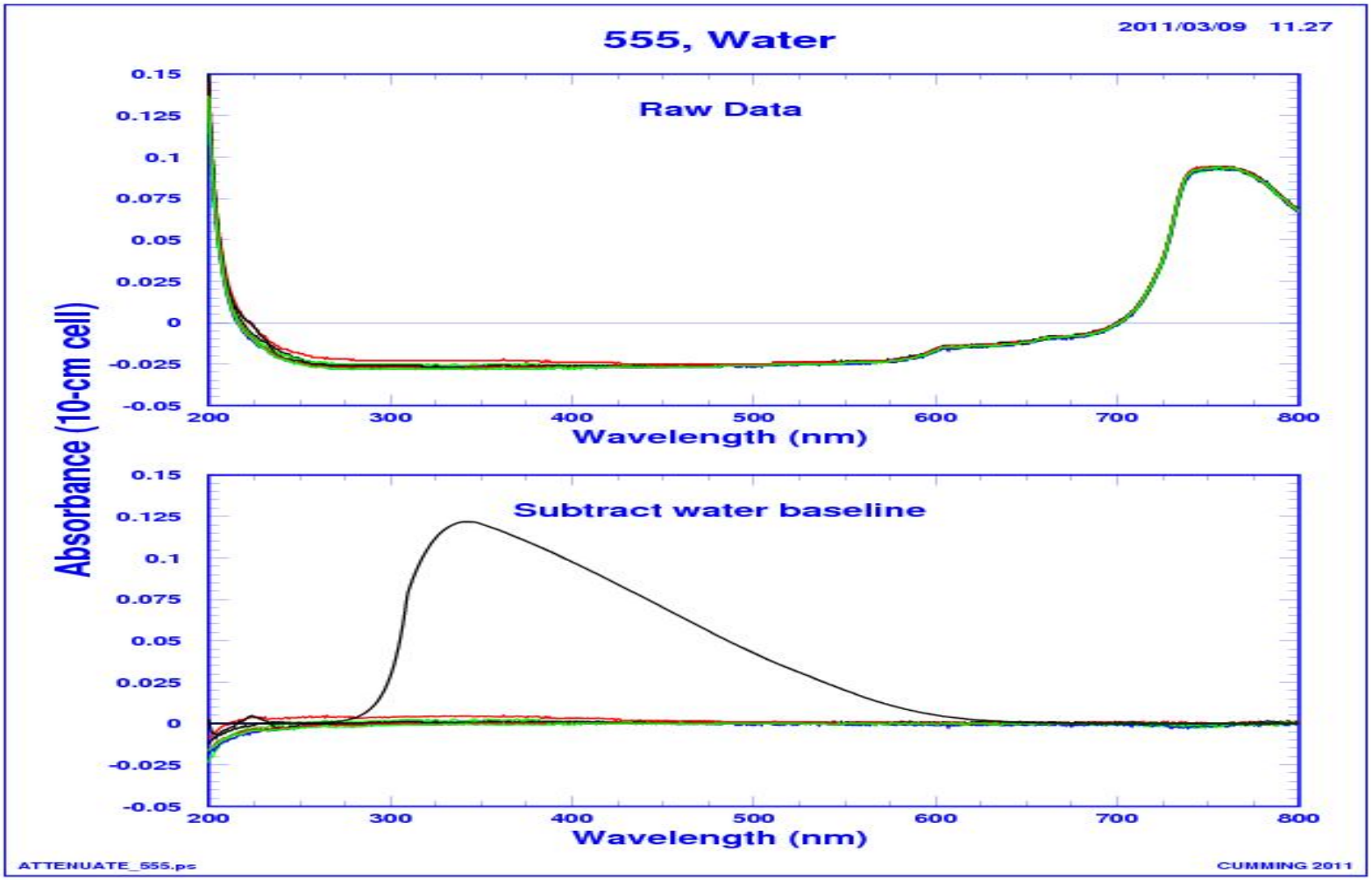
$$\Delta\% = \delta Ax \frac{S/V_{aging}}{S/V_{LBNE}} x \frac{1}{t_{aging} x Q_{10}^{\frac{T_{aging}-T_{LBNE}}{10}}}$$

KINETIC MODELING STUDY FOR WATER FILLED DETECTOR PMT AND WATER CERENKOV

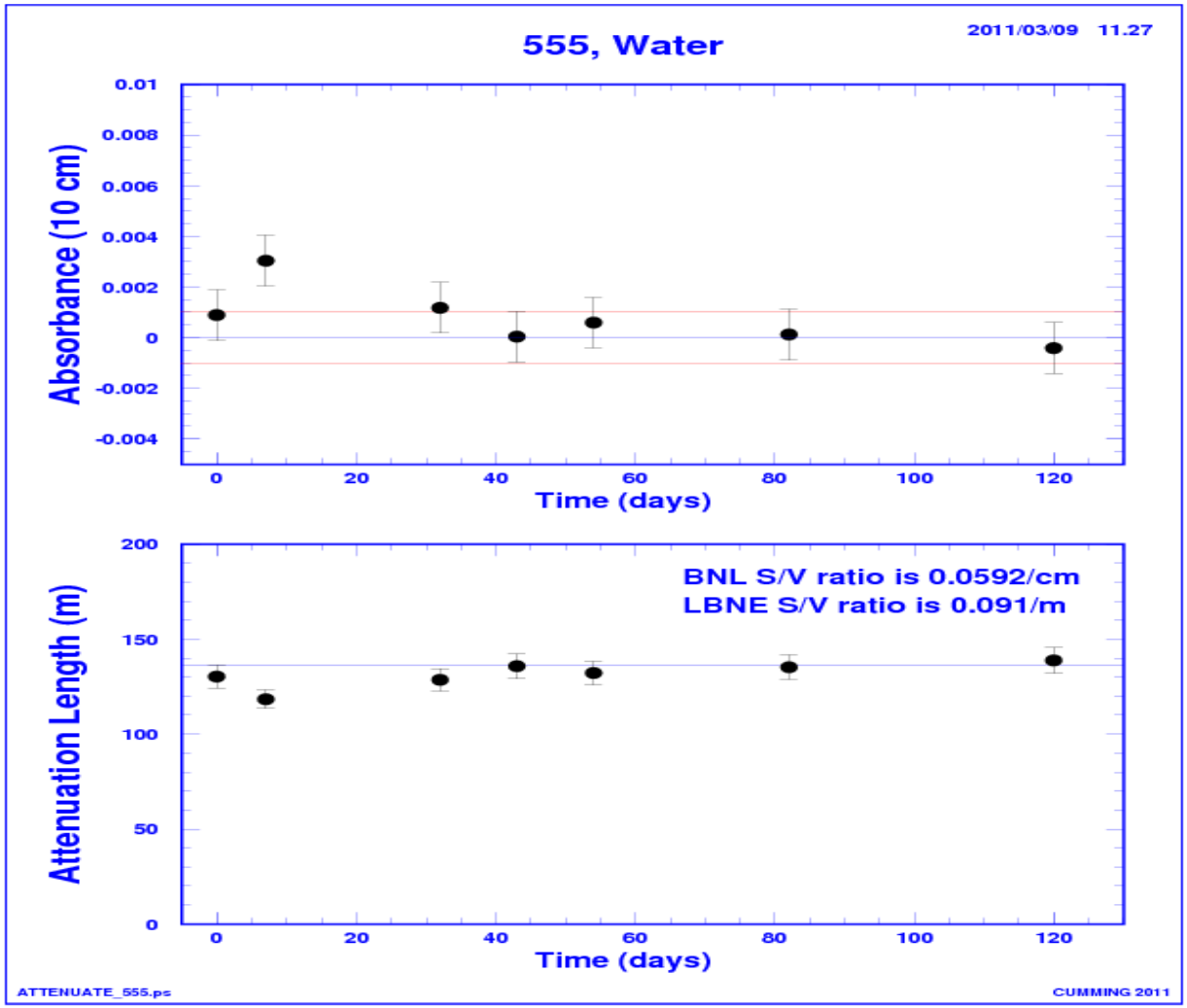




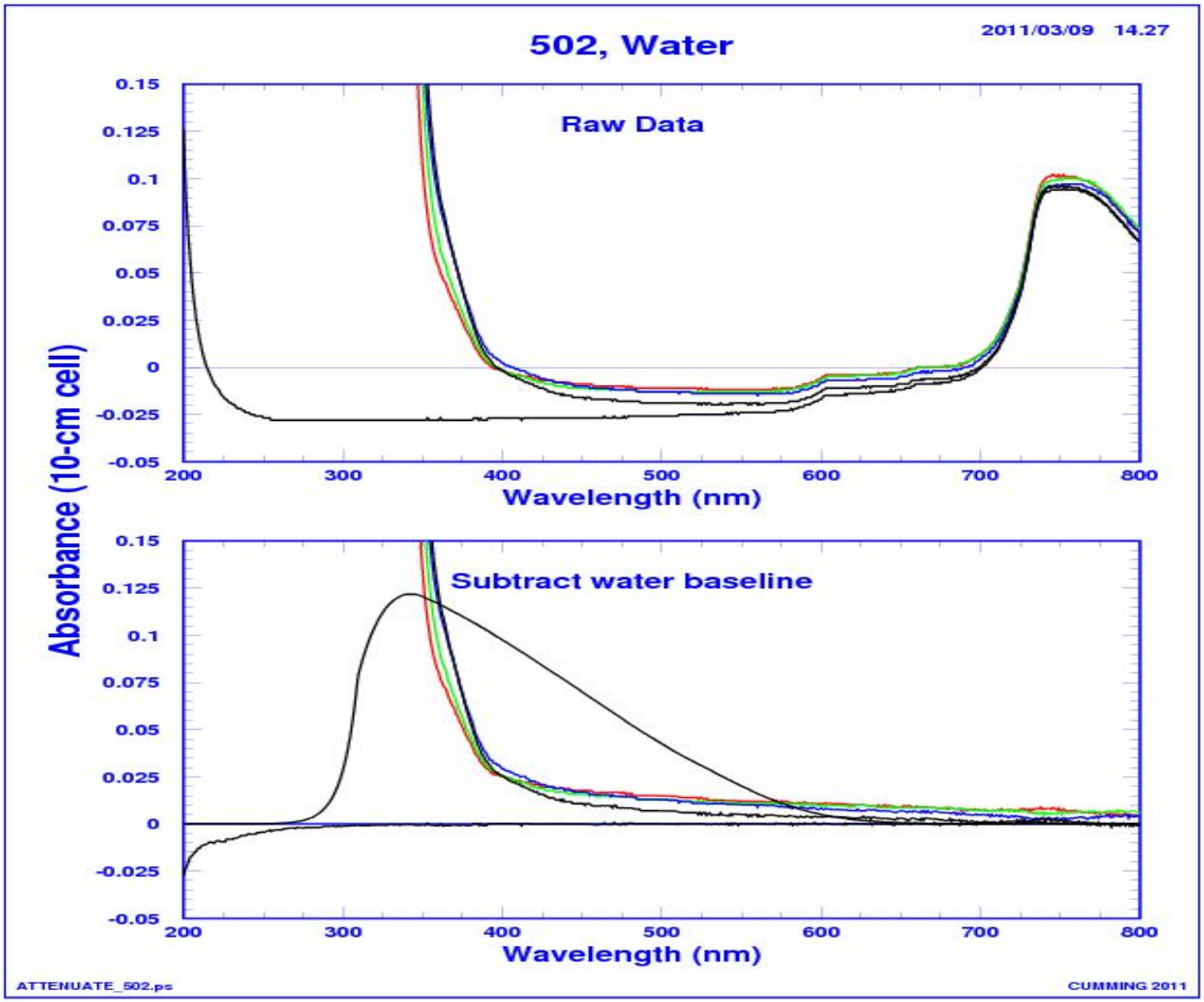
ACCEPTABLE MATERIAL SAMPLE



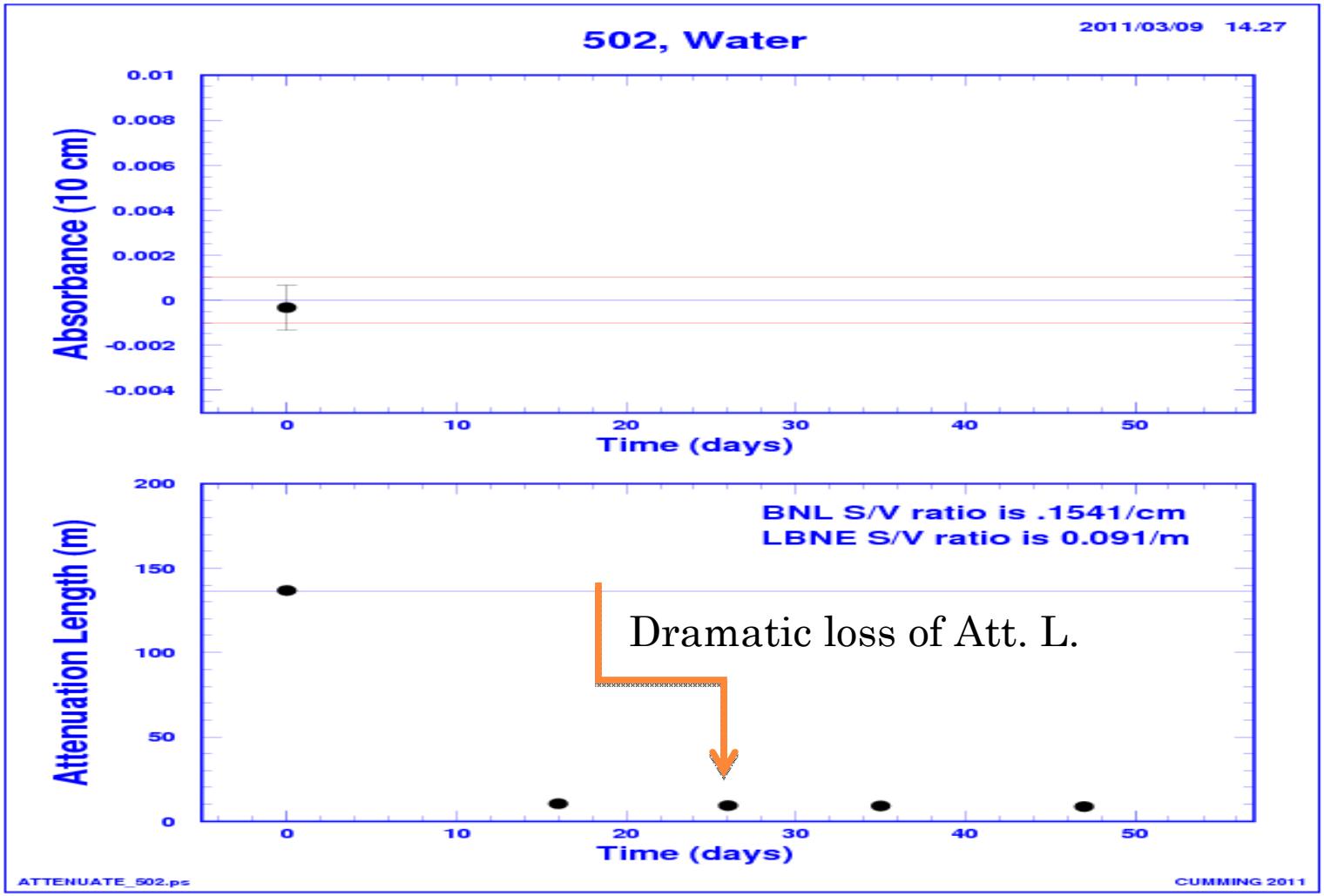
ATTENUATION LENGTH



UNACCEPABLE MATERIAL



Attenuation length



Detector Samples	Experimental Surface /Volume	Leaching effect on the Attenuation length
Liner material	$0.091 m^{-1}$	136 - ?
PMT	?	
Potting (polymer)	?	
Cables	?	
Unistrut	?	
PMT ladders	?	
Others	?	
Calibration material extra	?	
		136 – total AL loss due to leaching

Can purification system improve the water quality?

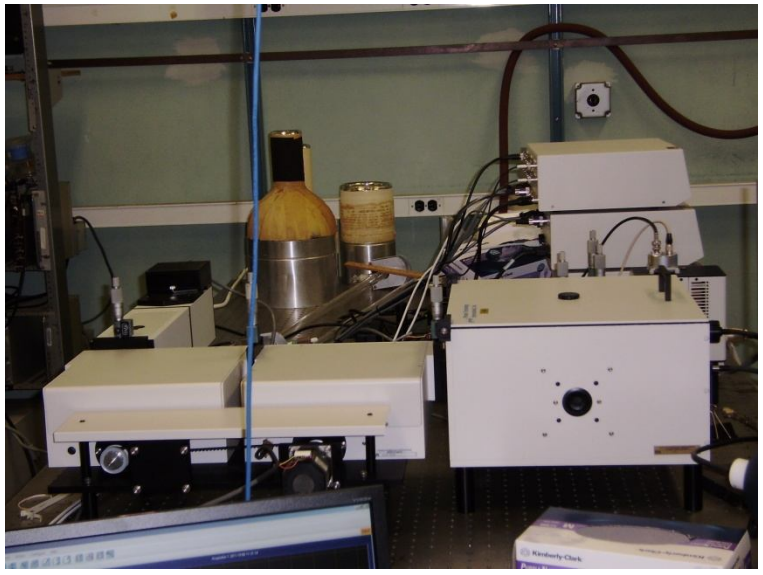
MATERIAL TESTING LAB

Instruments used for Analysis

XRF

UV-VIS

FTIR Qualification and quantification



Florescence Spectrometer
Excitation, Emission, and lifetime of LS

Instruments……

GCMS

Water Purification System

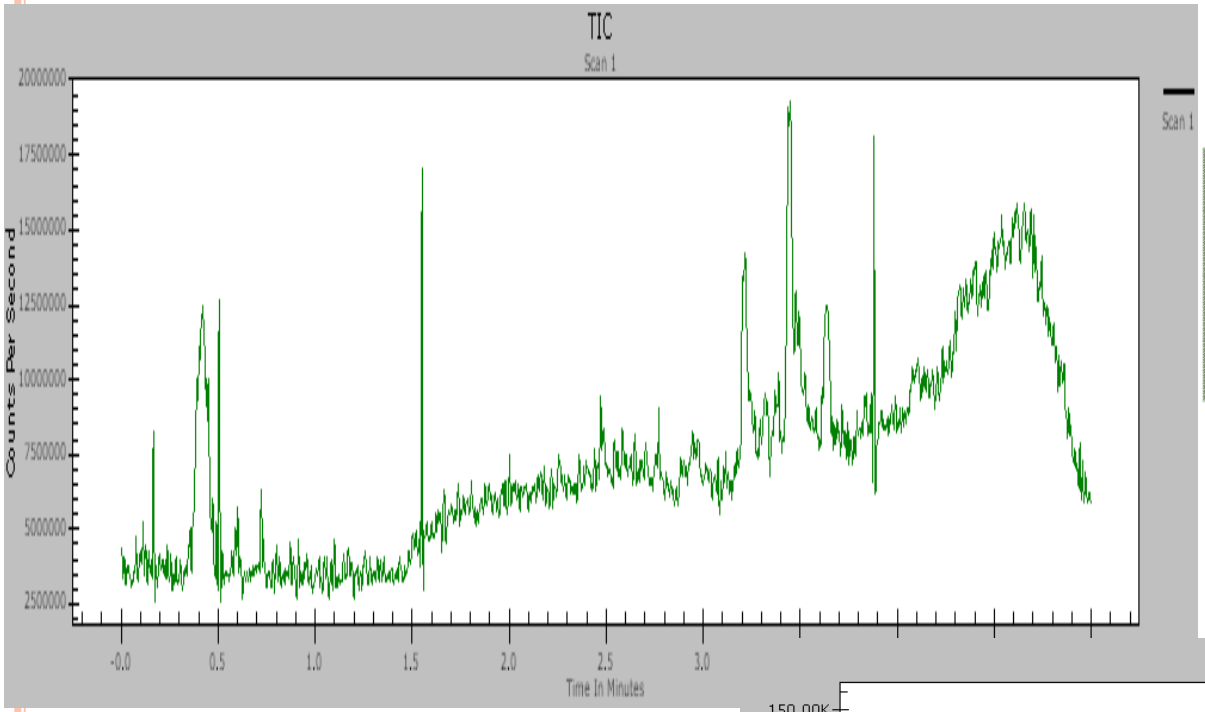
L1/e (att. length) by 2-m dual-beam, vertical LED system

Leaching identification

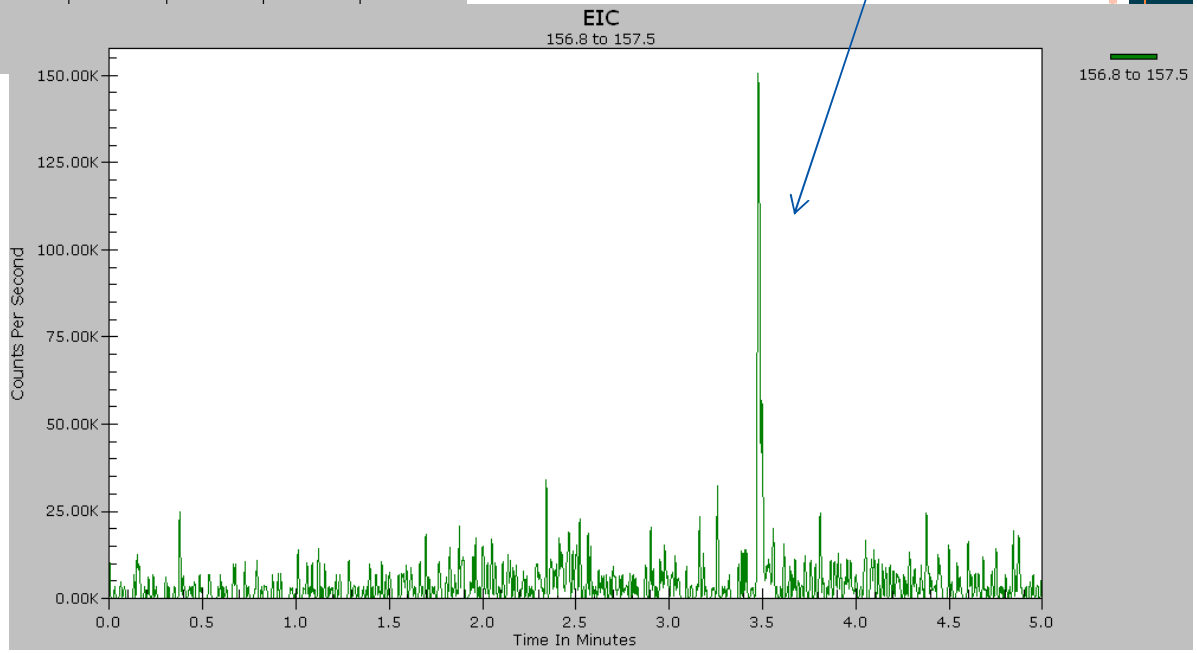
LCMS

- Plan of purchasing LCMS in near future
- Cut down the time for the detection of the leaching by identifying the leaching…

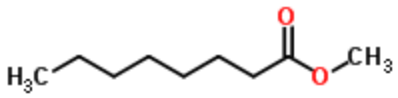
Sample 458 TIC vs. EIC of m/z 157



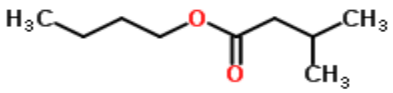
Using EIC allows for peaks to be seen that may be hidden behind other matrices such as solvent contaminants.



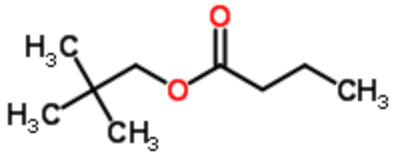
C9H18O2 (Add an H for formula) in Chemspider



Methyloctanoat



Butyl 3-methylbutanoate

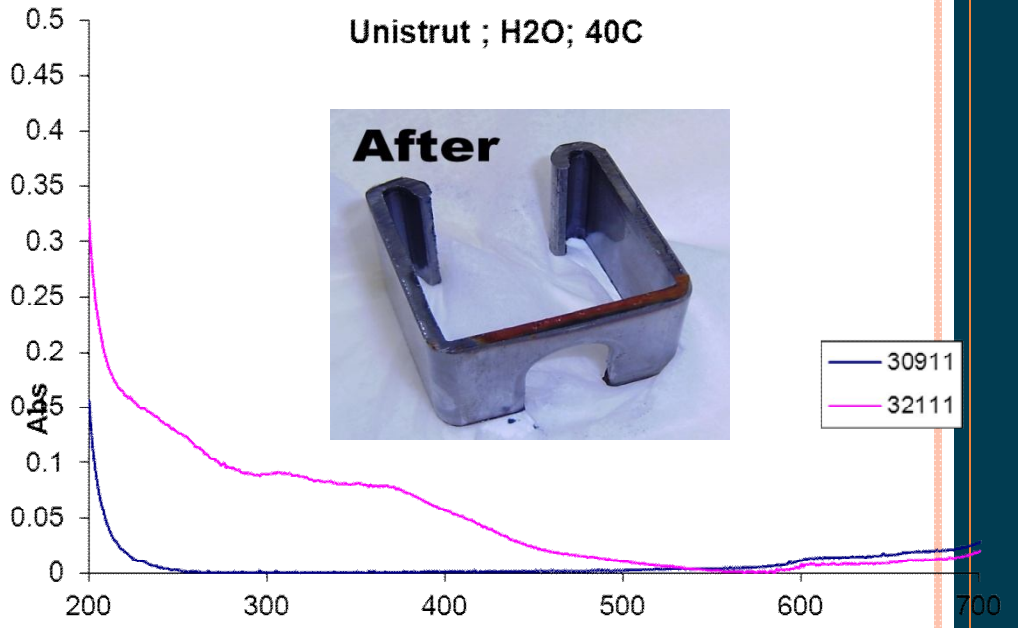


2,2-dimethylpropyl butanoate

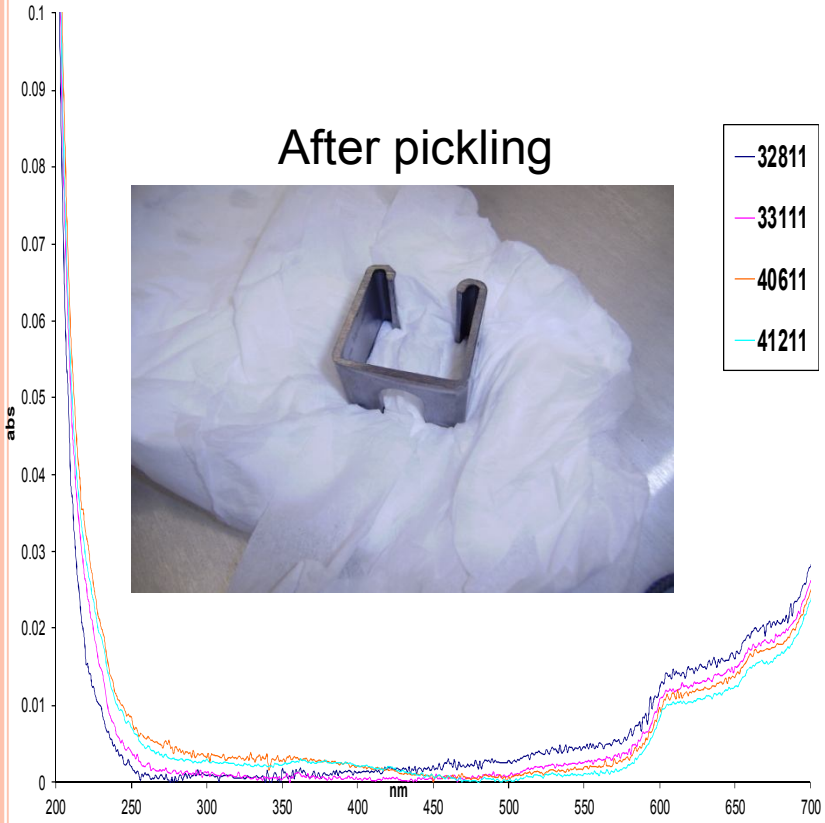
ChemSpider can be used to search by formula or exact mass. A few examples of the structure and name of some of the molecules that have the formula C9H18O2 are shown

http://www.chemspider.com/Search.aspx?t=adv&rid=30d2a16a-b855-4e14-9f6c-611aedd0019d

Water Filled Detector
Established pre-cleaning (pickling) methods
Unistrut

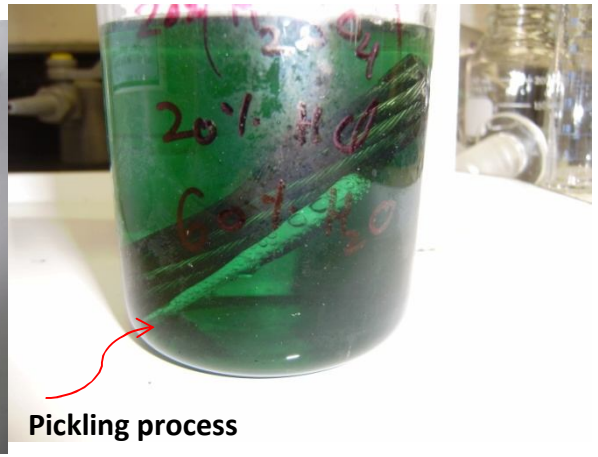


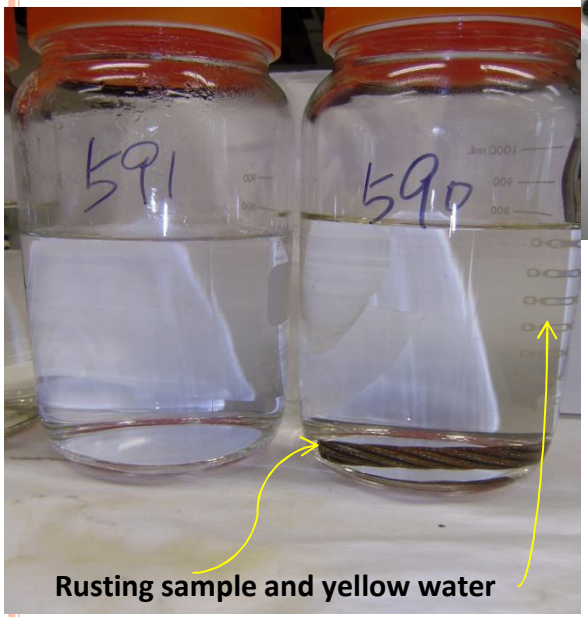
After pickling



Liner PIU Cable

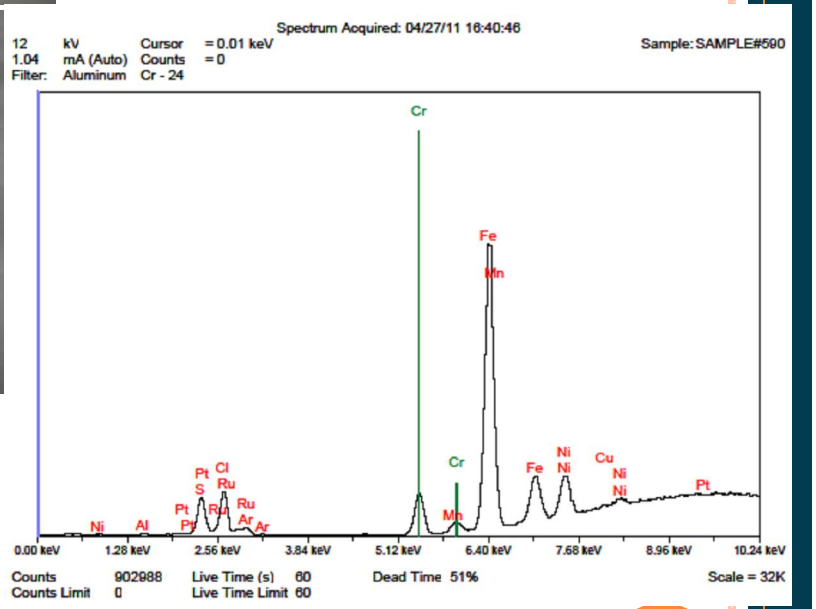

Sample broken apart into pieces at 40°C


Pickling process



Rusting sample and yellow water


After Pickling



- First testing of PIU cable failed due to rusting of the sample and tremendous amount of leaching was observed into the water
- Overnight pickling was done and sample was stick back in for the testing again
- Pickling solution analysis showed the chromium and nickel present in the solution

GOAL TO BUILD A MATERIAL COMPATIBILITY DATABASE FOR BROAD SCIENCE COMMUNITY

Tested ~700 materials

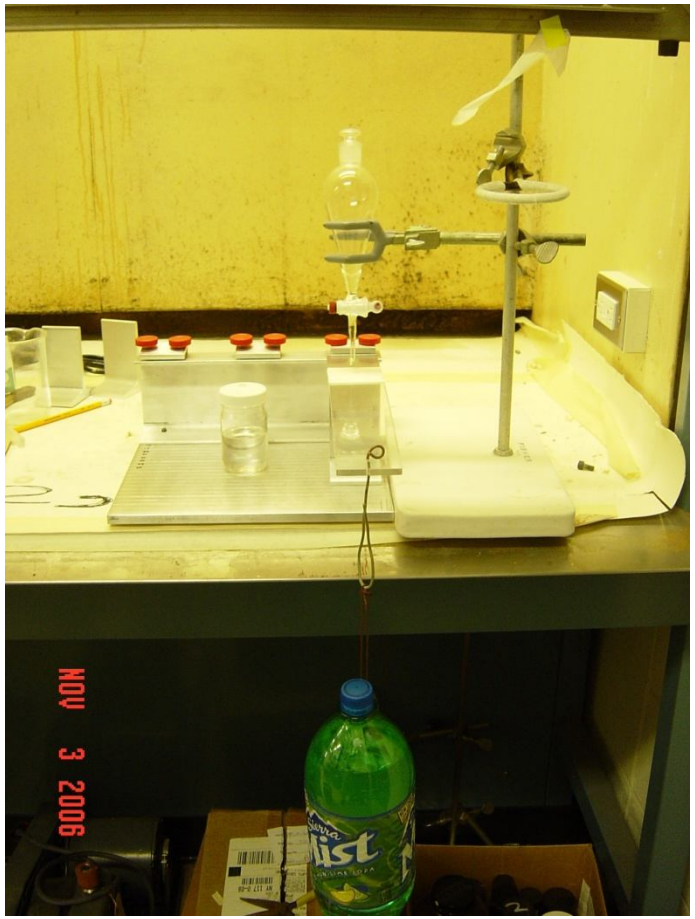
Good Samples Tested in Water

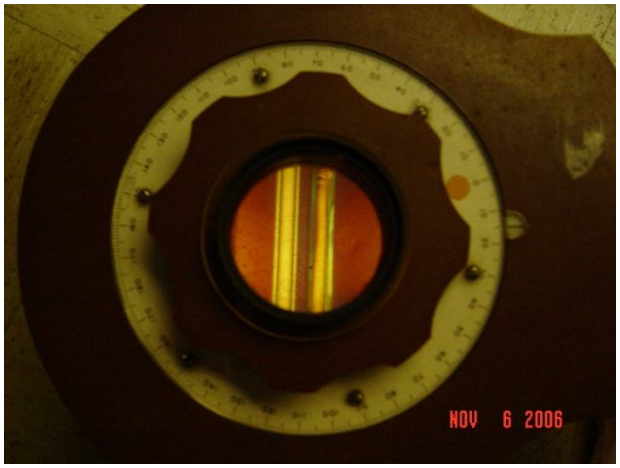
Model with Part no	Usage	Surface Area	Vendor (tel. address, etc)
RG-303 Belden YR-29304		1.40E-03	Beldin, Inc. 7733 Forsyth Boulevard, Suite 800 St. Louis, Missouri 63105 USA 800-BELDEN-1
Super Eslo Clean Pipe (HI-PVC)	pipe between halls	2.20E-03	Valves, Industrial Pipes & Materials Division
Black, flexible, PP cable tie	in pool water	5.80E-04	All-States Inc.
100mm PP Float Ball (Normal)	in pool water to support cover	0.116	Orange Products
304 CRES, part no # EX-2171A nut		3.76E-06	E/M coating services A division of metal improvement Co 6940 Farmdale Ave, North Hollywood, CA 91605 phone (323)-875-0101
304 CRES, part no # EX-2171A bolt		3.76E-06	
304 CRES, part no # EX-2171B nut		3.76E-06	
304 CRES, part no # EX-2171B bolt		3.76E-06	
RPP-7845 JWPW 05	Liner	0.091	Cooley group
VL-009 GSE Conductive White smooth, 60mil, HDPE	Liner	0.091	GSE
VL-010 GSE Conductive Smooth, 60mil HDPE	Liner	0.091	GSE
PSL VL-011 GSE HD Smooth, 60mil HDPE	Liner	0.091	GSE
PSL VL-012 GSE Ultra Flex Textured, 60mil LLDPE	Liner	0.091	GSE
PSL VL-013 GSE HD Textured; 40mil HDPE	Liner	0.091	GSE
PSL VL-014 GSE Ultra Flex Smooth, 60mil LLDPE	Liner	0.091	GSE
VL000 Uncoated SS316	Liner	0.091	
PSL VL015 Green Plastics Virgin HDPE, 62mil	Liner	0.091	
PSL MS001 (Magnetic Shielding)	Magnetic Shielding	0.00394	Bolshaya Cheremushkinskaya, 25, 117218 Moscow, Russia; http://www.itep.ru/eng/in_eng.shtml?rs_nonac.html
PSL VL016 Spray On Plastic's Five Star Polyurea	Liner	0.085	
Asahi PolyPure unpigmented (Natural Polypropylene)	pump water (from 4850m)	5.40E-02	
Asahi PP Pure pigmented (Natural Polypropylene)	pump water (from 4850m)	5.40E-02	Asahi/America, Inc.
Aquatherm Greenpipe, polyproplene	pump water (from 4850m)	5.40E-02	Aquatherm
Asahi Proline 150 pigmented	pump water (from 4850m)	5.40E-02	Asahi/America, Inc.
Custom Rubber Hose, EPDM	pump water (from 4850m)	5.84E-04	IVG Colbachini Spa (Italy)
PVT Base BC-499-76		0.196922	Saint Gobain Ceramics and Plastics Inc.

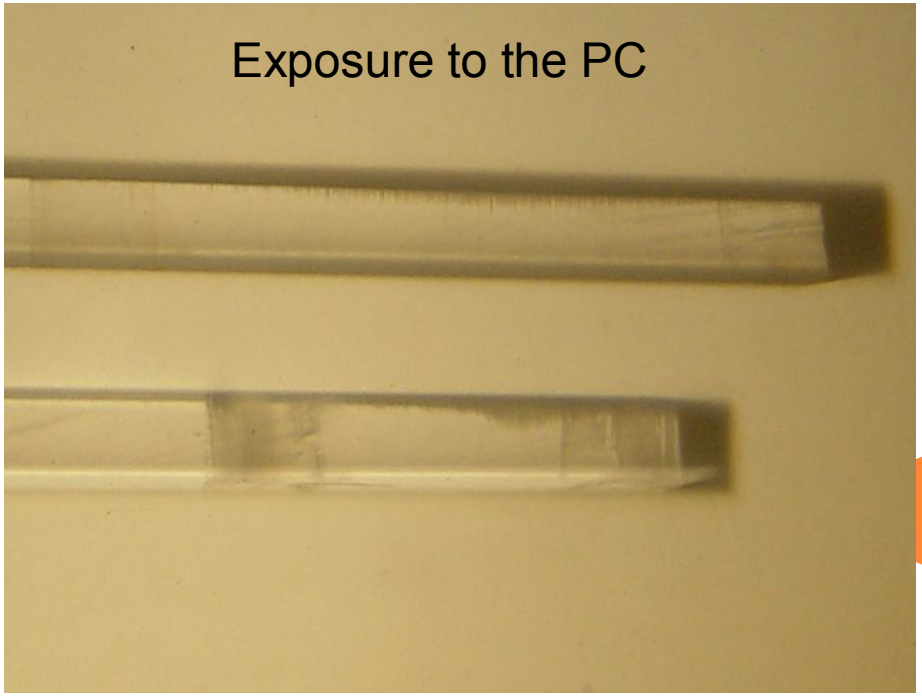
Good Materials in Organic Scintillator

Material	Reference Sample	Temperature
Teflon Disk	sample432	40
Viton O-ring	sample433	40
White Acrylic compatible with LS/GdLS from UW Physical Science	sample454	40
Black Acrylic compatible with LS/GdLS from UW Physical Science	sample455	40
Face of Ultrasonic Emitter; UW Physical Science	sample456	40
RG 303 cable	sample463	40
Ultra Soft Polyurethane	sample464	40
Fluorinated cupons	sample470	40
Krytox performance	sample478	40
Krytox performance	sample482	40
2 Springs (D25-022-3114)	sample488	40
3 ring steel (D25-020-1012)	sample489	40
3 bowl shape plates (D25-021-1011)	sample490	40
3 small viton rings (D25-047-2111)	sample491	40
1 viton ring (D10-083-2111)	sample492	40
1 Medium viton ring (D25-073-2111)	sample493	40
1 big viton ring (D25-109-2111)	sample494a	40
3 flat viton rings(D25-092-2111)	sample495	40
3 round viton rings(D25-035-2111)	sample496	40
Nylon	sample504	40
acrylic D	sample505	40
Stainless Steel plates	sample507	40
SS316 disk	sample508	40
Black vinyl faom from MCMaster carr# 8512K64	sample511	40
Polyethylene foam strip (white) from Mc Master Carr# 93565K55	sample512	40
Acrylic with layer of epoxy # 2216 by 3M	sample516	40

ORGANIC LIQUID SCINTILLATOR STRESS TEST







SUMMARY

- Selection of the compatible material is important
- Robust material compatibility program at BNL is growing
- BNL in the process of building a broad database for the all the future neutrino experiments
- An attenuation computational studies of the material testing program at BNL which will incorporate the online purification system. This computational calculations would help different experiment for the online purifications of the detectors filled different fluids.